Advanced Accelerator Diagnostics Research

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Collaborations


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FERMI@ Trieste (IT):  S. DiMitri, D. Castronovo, M. Veronese
Goal: Development of Diagnostics for High Brightness Beams

Approach: employ beam based radiation to diagnose beam, e.g. OTR, OSR, ODR combined with innovative optical techniques

Present Focus:

1. High dynamic range beam/ halo imaging using digital micromirror array (DMD)
2. Transverse emittance and energy spread monitors based on interference of (OTR, OSR) produced by beam
3. Optical Transverse Phase Space Mapping
4. Noninvasive bunch length monitor using angular distribution (CDR)
5. Mitigation of coherent, nonlinear effects due to micro bunching (present and potential problem for all high current, low emittance FELs)
1) High Dynamic Range Beam/Halo Imaging system*

High DR Imaging of JLAB CW Beam using OSR and DMD

\( I_b = 0.63 \text{ mA, } 4.68\text{MHz, } 135\text{pc/micropulse} \)

\[ E_{\text{Total}} \equiv \int I(x, y)dx\,dy \]

- Total 6 decades
- First 2 decades: \( E \sim 0.99 E_{\text{Total}} \)
- Last 4 decades: \( E \sim 0.01 E_{\text{Total}} \)

R. Fiorito, et. al. Proc. BIW12
2) Optical phase space mapping

Uses optical mask and beam radiation to measure beam divergence and trajectory angle measurements as function of position within beam image.

[Image 183x248 to 578x416]
[Image 50x75 to 744x224]

OPSM with OTR & Moving Pinhole Mask

3) Non Invasive Emittance Monitor using Optical Synchrotron Interferences (OSRI)*

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END
Extra Slides
Single Shot, Non invasive Bunch Length Diagnostic using Angular Distribution of CDR

\[
\frac{d^2 I_{bunch}^{DR}}{d\omega d\Omega} = \frac{d^2 I_e^{DR}(\omega)}{d\omega d\Omega} \left\{ N^2 S_\perp(k_\perp, \sigma_T)S_z(\sigma_z, k_z) \right\}
\]

Spectral-Angular Distribution of DR from single electron is frequency dependent

Concept: choose the size and shape of the radiator so that it is sensitive to the range of bunch sizes under investigation and use the frequency integrated AD to measure it.

Longitudinal form factor depends on Bunch Length
Example: Angular distribution of CTR from Finite Disk (CDR)
\( (E=100 \text{ MeV}) \)

Projected Angular Distributions, \( J(w,p) \)

Bunch Form factors for various Gaussian pulse widths and CTR spectrum

Frequency Integrated Broad Band Power, \( W(p) \) for various pulse widths

\[ W(p) = \int_{\omega_1}^{\omega_2} J(\omega, p)S_{\mathrm{f}}(\omega) d\omega \]

A.Shkvarunets and R.Fiorito, PRSTAB (2008)
Proof of Principle Experiments at PSI, SLS’s 100 MeV LINAC using scanning Golay cell

Interceptive

CTR from plate

Non Interceptive

CDR from Slit

<table>
<thead>
<tr>
<th>Method</th>
<th>Tune</th>
<th>T(ps)</th>
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<tbody>
<tr>
<td>AD CTR/CDR</td>
<td>PBU-0</td>
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<tr>
<td>E-O technique</td>
<td>PBU-0</td>
<td>0.75</td>
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<tr>
<td>AD CTR/CDR</td>
<td>PBU+3</td>
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R.Fiorito, et al.
Proc. of DIPAC 2007